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STATISTICAL ANALYSIS OF THE DISTRIBUTION OF SNOW COVER DEPTH IN--ETC(U)
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(6) STATISTICAL ANALYSIS OF THE DISTRIBUTION OF SNOW COVER DEPTH IN SMALL MOUNTAINOUS AREAS.

(Statisticheskii Analiz Raspredeleniia Glubiny Snezhnogo Pokrova na Malykh Ploshchadiakh V. Gorakh).

(10) A.A. Chirkova

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This work makes an attempt to estimate the amount of snow cover in areas comparable to the dimensions of a snow (observation) post using statistical methods. The original material was the results of special snow-measuring surveys conducted in 1967, 1971 and 1972 in certain basins of western Tyan-Shan. The principles of choosing the area consisted in an attempt to find the most level parts of a slope and to hold the effect of characteristics of snow accumulation in any particular basin to a minimum. Measurements of the

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depth of snow cover were made along lines 50 m long rigidly held in place: in 6 cases along four mutually intersecting lines, and in 4 cases along the perimeter of a square. Distance was fixed with the aid of a measuring tape every 20 or 50 cm. A total of 28 series of snow surveys was carried out.

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NOTICE

THE STATISTICAL ANALYSIS OF THE DISTRIBUTION OF SNOW COVER DEPTH IN SMALL MOUNTAINOUS AREAS

By: A. A. Chirkova

Questions of improving the efficiency of the snow-measuring system, despite significant experience recently accumulated (1, 4, 5, 7, 14, 15), still remain pressing ones: first, because of the increase in information about the statistical structure of the snow reserve field, and second, because of the necessity of constructing a system using new means of data transmission, and finally, in connection with the practical requirements of differentiated estimates of snow reserves.

This work makes an attempt to estimate the amount of snow cover in areas comparable to the dimensions of a snow (observation) post using statistical methods. The original material was the results of special snow-measuring surveys conducted in 1967, 1971 and 1972 in certain basins of western Tyan'-Shan'.

The principles of choosing the area consisted in an attempt to find the most level parts of a slope and to hold the effect of characteristics of snow accumulation in any particular basin to a minimum. Measurements of the depth of snow cover were made along lines 50 m long rigidly held in place: in 6 cases along four mutually intersecting lines, and in 4 cases along the perimeter of a square. Distance was fixed with the aid of a measuring tape every 20 or 50 cm. A total of 28 series of snow surveys was carried out.

Statistical analysis of the obtained data started with a check of the assumption of homogeneity of the studied field.

A field of mean values of the height of the snow cover, followed by the dispersion field, was primarily investigated. The Student criterion was used to test the equality (homogeneity) of two means

$$t=\frac{\bar{x}_1-\bar{x}_2}{\sqrt{n_1\sigma_1^2+n_2\sigma_2^2}}\sqrt{\frac{n_1n_2(n_1+n_2-2)}{n_1+n_2}},$$

where $\bar{x}_1$ and $\bar{x}_2$ - the random means; σ_1 and σ_2 - random dispersions; n_1 and n_2 - number of memebers of the first and second samples; $(n_1 + n_2 - 2)$ - number of degrees of freedom.

For normally distributed samples at the q %-level of significance, deviation between the centers of distribution is considered significant if the following condition is satisfied

$$|t| > t_q.$$

The boundaries of the critical region have been tabulated and cited in works (8, 13) for a Student distribution.

The results of the test given in Table 1 show that in most cases the random

Student statistic exceeds the critical value at the 5-percentile level of significance ($t_{5\%} = 1.96$).

We note that the use of the Student criterion is valid with the condition of equality of dispersions and can lead to erroneous conclusions when this requirement is not observed. Therefore, in addition to testing the equality of dispersions, the affiliation of the means to a single set was randomly tested again according to the criteria of signs not limited by the equality of dispersions. As in the preceding case, the results of the test validated the hypothesis of homogeneity of mean values.

The F-statistic of Fischer was used to test the equality of dispersions. This statistic makes it possible to determine the significance of deviations among the analyzed dispersions. The difference is recognized as significant if the following condition is satisfied

$$F > F_q.$$

The determination of the criterion which depends solely on the number of degrees of freedom pertains to calculating the value

$$F = \frac{s_1^2}{s_2^2},$$

where s_1^2 is always the greater of the examined values. In this case the estimate of dispersion is determined for each measured line and for the entire realization as a whole. The 5-percentile level is taken as the calculation level.

The calculated values of the Fischer criterion for most cases were over the critical ones, which indicates the existence of differences of dispersions (Table 1). It is physically difficult to explain the obtained results, inasmuch as the conditions of snowfall and snow deposit within the confines of the experimental areas are practically unaltered. Analysis of the Fischer statsitics obtained for each measuring line detects an effect of a certain factor. To our view, this could be the character of the underlying surface. Because of this, the significance of its effect on the random nature of the sample was investigated. The estimate was made with the aid of the successive differentials methods (the Neiman relationship), in which the random dispersion is estimated in two ways:

$$s^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \overline{x})^2,$$

$$c^2 = \frac{1}{2(n-1)}\sum_{i=1}^{n}(x_{i+1} - x_i)^2.$$

Estimates c^2 and s^2 react differently to a change in the center of the distribution. The former is less sensitive to the trend of the mean value, while the latter sharply increases in the presence of even a weak trend.

Таблица 1

Проверка на однородность средних значений глубины снега с помощью критерия Стьюдента (1) и дисперсий с помощью критерия Фишера (2) при 5%-ном уровне значимости

1

Дата измерений 2	1) $t_q = 1{,}96$				2) $F_q = 1{,}26$			
	3 промерная линия							
	1–2nd	2–3rd	3–4th	4–1st	1–2nd	2–3rd	3–4th	4–1st
				4 Кызылча				
1971								
24 I	3,08	2,92	5,82	0,01	2,12	1,00	2,16	1,03
27 II	6,37	0,01		2,07	1,66	1,23		1,15
28 III	6,29	3,17	6,24	0,01	1,01	1,08	1,06	1,00
				5 Наугарзан				
1971								
10 II	5,24	4,56	5,46	1,80	1,55	2,60	1,30	1,06
26 II	3,84	0,62		2,23	1,50	2,50		1,44
				6 Ойгаинг				
1971								
29 I	3,48	6,18	6,06	2,30	1,02	2,62	1,82	1,12
30 III	5,64	7,09		1,18	1,33	3,52		2,82
1972								
31 I	5,23	0,01	0,01	2,62	1,08	1,23	1,02	1,45
29 II	2,50	2,51	4,77	5,74	1,07	1,00	2,32	2,05
31 III	1,74	3,30	5,06	4,90	2,22	1,04	1,35	1,02
				7 Ледник Северцова				
1971								
31 I	0,01	3,84	0,01	0,97	2,57	1,31	1,27	2,55
3 III	3,67	3,52	3,58	4,10	4,42	1,73	2,30	1,98
31 III	7,57	4,34	0,01	0,81	5,23	1,20	2,69	1,70
1972								
2 II	0,01	1,09	0,01	5,23	1,04	1,67	1,66	1,02
1 III	2,87	3,89	3,00	5,51	1,00	1,21	2,09	1,46
31 III	3,85	4,06	6,80	5,35	1,48	3,78	1,54	1,50

Key for Table 1:

1 - Table 1. Homogeneity test of average values of snow depth with the aid of the Student criterion (1) and of dispersions with the aid of the Fischer criterion (2) at the 5-percentile significance level.
2 - date of measurements
3 - measuring line
4 - Kyzylcha
5 - Naugarzan
6 - Oygaing
7 - Lednik Severtsova

(Note: commas should be read as decimals.)

When the sample has a large volume the relationship

$$\tau = \frac{c^2}{s^2}$$

approximates the normal and therefore, one can use the quantiles of normal distribution, whose tables are given in a number of works, to determine the boundaries of the critical region

$$\tau_q = 1 - \frac{t_q \sqrt{n-2}}{n-1}.$$

The trend is significant if $\tau < \tau_g$ at the assigned level of significance.

In the examined case, when q = 5% and n = 100, the critical value $\tau = 0.835$, and, as is evident from Table 2, it significantly exceeds the calculated values which are near zero everywhere, which is a characteristics of the correlated initial data (12). Consequently, the hypothesis of the random nature of the original field contradicts the experimental data and should be discarded. Undoubtedly, this is the reason why the homogeneity hypothesis was overturned, inasmuch as it is known that the hypothesis does not take into account the intraset relations and leads to taking patently homogeneous data as heterogeneous ones (12). Therefore, subsequently, one should designate the interval between measurements in order to ensure independence of the original data.

Some of the estimates used above (the parameteric criteria) depends significantly on the normality of the distribution and for this reason require a basis for the validity of their use. At the same time, opinions which exist in the literature concerning the form of snow cover distribution are extremely contradictory. Some authors (2, 3, 11) assume that the snow has a normal, or at least normal distribution, while others (10, 16) include the snow cover among phenomena with a clearly pronounced asymmetry.

The task of the investigation the authors conducted, first, was to establish the law of distribution in small areas, and second, to analyze the existence of a deviation of the original theories from the normal law. In order to describe the type of distribution of the snow cover, the widely popular Pearson curves were used. For such curves, methods and systems of calculation are well developed. In our case, smoothing of the empirical frequencies was carried out according to the system presented in (8).

The calculations were carried out on a computer according to a program compiled by G. Ye. Glazyrin (SARNIGMI), which provides not only for the choice of the type of Pearson curve, but also for a comparison of the empirical frequencies with those chosen with the aid of the Pearson agreement criterion. The program also provides for analog operations with a normal curve additionally entered into the analysis. In parallel with the Pearson criterion, the hypothesis of the correspondence of empirical data to the suggested theoretical law was tested according to the Kolmogorov criterion, since the Pearson criterion significantly differs from the quite arbitrarily accomplished grouping,

and furthermore, the use of the maximum law of distribution with small volumes of the sample will lead to the recognition of a zero hypothesis even for significantly different distributions, while for large samples, on the other hand, it frequently refutes the zero hypothesis (6).

In both cases, the assumption was made for the zero hypothesis that the examined sample is distributed according to the hypothetically theoretical law.

The following expression is used as a measure of deviations in the Pearson criterion

$$\chi^2 = \sum_{i=1}^{l} \frac{(n_i' - \tilde{n}_i)^2}{\tilde{n}_i},$$

where n_i' - empirical frequencies; $\tilde{n}_i$ - smoothed frequencies; l - number of gradations.

At the 5%-level of significance, the critical region for testing the hypothesis has the following form:

$$\chi^2 \leqslant \chi^2_q.$$

The results of the check are given in Table 3. In analyzing the tabular data, it is impossible to give preference to either asymmetrical or symmetrical distribution: the appearance of both the first and second curves is practically equiprobable. Thus, of 50 cases, Pearson curves of the first, third, fourth and sixth types (asymmetrical) are encountered 22 times, and in 28 cases the χ^2 criterion satisfies the requirements of curves of the symmetrical type (2 and 7). Both kinds of distribution are observed at all experimental sites, independent of the uniqueness of these sites. The asymmetrical distribution predominates only in regions with pronounced wind activity. One also notes a tendency of more frequent manifestation of the asymmetrical curves in the snow thaw period.

The Kolmogorov criterion is based on a comparison of the integral distribution functions. The measure of deviation here is the greatest difference between the empirical and theoretical functions relative to absolute magnitude.

$$D = \max \left| P_i' - P_i \right|.$$

The statistic $\lambda = D\sqrt{nc}$ with a critical probability of $K(\lambda) = 0.5$ means that deviations between the examined distributions are due to random factors and are not significant.

The results of the test are given in Table 3. According to this criterion, the symmetrical Pearson curves are encountered 41 times and the asymmetrical ones are encountered 36 times. It is more important to note that if a normal distribution was found in 44 samples of the 103 investigated ones according to the Pearson criterion, then during the use of the Kolmogorov criterion the model of normal distribution can be accepted in 78 cases.

Таблица 2

Проверка на случайность измерений глубины снежного покрова методом последовательных разностей 1

Дата измерений 2	3 Промерная линия							
	1–2nd	1–3rd	1–4th	1–5th	1–6th	1–7th	1–8th	1–9th
4 **Кызылча** ($n = 100$, $q = 5\%$, $\tau_q = 0{,}835$)								
1971								
24/I	0,40	0,49	0,07	0,24				
27/II	0,11	0,40		0,11				
28/III	0,03	0,16	0,15	0,07				
5 **Наугарзан** ($n = 100$, $q = 5\%$, $\tau_q = 0{,}835$)								
1971								
10/II	0,18	0,08	0,05	0,02				
27/II	0,16	0,02		0,02				
6 **Ойгаинг** ($n = 100$, $q = 5\%$, $\tau_q = 0{,}835$)								
1971								
29/I	0,08	0,15	0,11	0,14				
30/III	0,11	0,11		0,19				
1972								
31/I	0,11	0,19	0,18	0,24				
29/II	0,24	0,19	0,05	0,22				
31/III	0,41	0,22	0,29	0,24				
7 **Ледник Северцова** ($n = 100$, $q = 5\%$, $\tau_q = 0{,}835$)								
1971								
31/I	0,24	0,29	0,17	0,25				
3/III	0,20	0,19	0,16	0,13				
31/III	0,01	0,04	0,15	0,10				
1972								
2/II	0,12	0,10	0,05	0,07				
1/III	0,14	0,08	0,07	0,08				
31/III	0,08	0,30	0,06	0,03				
8 **Дукант-1** ($n = 250$, $q = 5\%$, $\tau_q = 0{,}896$)								
1967								
6/II	0,20	0,27	0,11	0,11	0,10	0,22	0,21	0,17
21/II	0,44	0,48	0,24	0,44	0,13	0,32	0,60	0,51
13/III	0,19	0,03	0,01	0,01	0,62	0,19	0,15	0,17
9 **Дукант-2** ($n = 250$, $q = 5\%$, $\tau_q = 0{,}896$)								
1977								
9/II	0,20		0,13		0,05		0,21	
11/II	0,13	0,14	0,01	0,17	0,40	0,12	0,08	0,05
22/II	0,31	0,11	0,30	0,22	0,61	0,37	0,19	0,17

Key for Table 2:

1 - Table 2. A check for the random nature of snow cover depth measurements by the successive differential method.
2 - date of measurements
3 - measuring line
4 - Kyzylcha
5 - Naugarzan
6 - Oygaing
7 - Lednik Severtsova
8 - Dukant-1
9 - Dukant-2

This conclusion is a very important one in a practical regard, since it imparts a justification to the calculations done above and makes it possible to determine what volume of observations one should have to find the mean values with an assigned level of error and probability.

In comparing the results obtained by means of calculating the χ^2 criterion and the Kolmogorov criterion for the hypothesis of correspondence of the sample data to the theoretical law, it is easy to see that on the whole both criteria agree well. It is only for samples with the lowest probability ($K_{(\lambda)} = 0.30$) of statistic λ that the χ^2 criterion produces a negative result.

We now proceed to determine the minimum number of measurements according to a formula known in statistics:

$$n = \frac{t_p^2 c_v^2}{\varepsilon^2},$$

where t_p is a value determined at an assigned probability P in tables of values of the probability integral; c_v is a measure of changeability (the coefficient of changeability); ε is the permissible relative error. Usually, in the practice of scientific investigations, the probability value is assumed to be P = 0.95 or P = 0.99, while the permissible measurement error is established depending upon the nature of the phenomenon. As the investigations of I. A. Il'in (SARNIGMI) showed, in 90% of the cases the possible error in determining the average depth of the snow does not exceed 10% in the period of build-up of the snow cover with a certainty value of 0.95. In March the error increases and in the same 90% of the cases already comprises about 20%. These investigations were carried out according to the data of snow-measuring posts in mountain basins of Central Asia. The results of the calculation at a certainty level of 0.95 in an error of 0.5 in one case and 0.10 in another are given in Table 4. It is entirely obvious that one cannot have a uniform solution when one selects the error of determining the mean. With precisely the same number of measurements, the error of averaging will first be different at different times of snow accumulation, and second, will be different for areas with a different degree of terrain brokenness: the greater the degree of brokenness of the terrain, the more measurements should be made in the area in order to obtain an average with an assigned level of accuracy.

Figure 1 visibly confirms the above. Here, on the axis of the ordinate, one has the necessary number of measurements calculated when $\varepsilon = 0.10$ and P = 0.95 for the period of build-up of the snow cover; on the axis of the abscissa one has the coefficient of changeability of terrain elevations over an arbitrarily selected area. The latter are values accepted as the index of terrain brokenness measured in the field. And there is still another important detail. In errors with wind redistribution of the snow cover (for example, in an area located in the Naugarzan River basin), the effect of the underlying surface is smoothed by changeability created by wind snow transport. In this case the number of necessary measurements in such areas increases many times in comparison with areas which are not subjected to the wind effect.

Таблица 3

Проверка гипотезы распределения измерений глубины снежного покрова с помощью критериев χ^2 (1) и Колмогорова (2) 1

Дата 2	Номер промерной линии 3	1: Кривая Пирсона 4: Число измерений 5	Вид кривой 6	$\chi^2_{выб.}$ 7	$\chi^2_{5\%}$	Оценка H_0 8	1: Нормальная кривая 9: $\chi^2_{выб.}$ 10	$\chi^2_{5\%}$	Оценка H_0 11	2: Кривые Пирсона 12: $K(\lambda)$	Оценка H_0 14	2: Нормальная кривая 13: $K(\lambda)$	Оценка H_0 15
							16 **Дукант-1**						
1967													
6 II	1—2	253	1	16,9	16,9	Да 18	31,4	19,7	Нет	0,94	Да	0,10	Да
	1—3	250	1	21,6	15,5	Нет 19	27,5	18,3	•	0,54	•	0,03	Нет
	1—4	247	2	14,1	14,1	Да	15,9	16,9	Да	0,93	•	0,48	Да
	1—5	250	1	60,6	18,3	Нет	87,0	21,0	Нет	0,16	•	0,00	Нет
	1—6	244	1	19,5	21,0	Да	37,3	16,9	•	0,92	•	0,11	Да
	1—7	250	2	15,5	15,5	•	26,0	18,3	•	0,00	Нет	0,15	•
	1—8	250	4	6,91	7,8	•	16,0	16,9	Да	0,94	Да	0,37	•
	1—9	250	7	18,3	18,3	•	15,9	16,9	•				
21 II	1—2	100	2										
	1—3	100	4				28,9	11,1	Нет			0,24	•
	1—4	100	2	12,1	15,5	•	10,2	14,1	Да	1,00	•	0,34	•
	1—5	100	1	8,25	11,1	•	20,1	14,1	Нет	1,00	•	0,12	•
	1—6	99	1				144,3	18,3	•			0,02	Нет
	1—7	101	6				12,7	9,5	•			0,56	Да
	1—8	100	3				2094	25,0	•			0,000	Нет
	1—9	100	3				8600	15,5	•			0,000	•
							17 **Дукант-2**						
9 II	1—2	250	1	25,3	7,8	Нет	1,14	11,1	Да	0,97	Да	0,27	Да
	1—3	248	1	30,0	7,8	•	15,9	12,6	Нет	0,004	Нет	0,01	Нет
	1—4	238	2				32,5	12,6	•			0,05	Да
	1—5	251	7	29,5	9,5	•	29,5	9,5	•	0,12	Да	0,12	•

continuation of Table 3:

Дата	Номер промерной линии	1								2			
		Кривая Пирсона					Нормальная кривая			Кривые Пирсона		Нормальная кривая	
		Число измерений	Вид кривой	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_0	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_0	$K_{(\lambda)}$	Оценка H_0	$K_{(\lambda)}$	Оценка H_0
11 II	1—2	250	1				68,6	16,9	Нет			0,006	Нет
	1—3	239	2	18,1	9,5	Нет	18,9	12,6	•	0,86	Да	0,79	Да
	1—4	206	2	31,0	9,5	•	47,7	12,6	•	0,50	•	0,002	Нет
	1—5	247	2	22,7	12,6	•	24,8	16,9	•	0,99	•	0,98	Да
	1—6	250	4				46,7	16,9	•			0,01	Нет
	1—7	244	2	37,2	11,1	•	35,1	14,1	•	0,58	•	0,05	•
	1—8	250	1	10,9	12,6	Да	32,5	15,5	•	0,92	•	0,42	Да
	1—9	218	2	10,7	14,1	•	16,4	14,1	•	0,93	•	0,82	•
22 II	1—2	100	2	10,0	12,6	•	7,58	9,5	Да	1,00	•	0,91	•
	1—3	80	2	6,80	7,8	•	8,50	11,1	•	1,00	•	0,61	•
	1—4	52	2				10,9	3,8	Нет			0,09	•
	1—5	80	3	15,7	6,0	Нет	14,9	9,5	•	0,92	•	0,13	•
	1—6	100	1				83,8	18,3	•			0,003	Нет
	1—7	92	2	12,2	16,9	Да	13,4	18,3	Да	0,97	•	0,38	Да
	1—8	92	2	8,07	11,1	•	12,1	15,5	•	0,91	•	0,71	•
	1—9	72	2	7,97	12,6	•	12,0	15,5	•	0,96	•	0,16	•
						Kyzylcha							
1974 24 I	tot.	400	7	7,84	12,6	Да	1,98	6,0	Да	0,99	Да	1,00	Да
	1—2	100	2	1,27	3,8	•	4,32	6,0	•	1,00	•	0,71	•
	2—3	100	7	11,8	9,5	Нет	29,7	14,1	Нет	0,63	•	0,50	•
	3—4	100	7	0,11	6,0	Да	0,94	6,0	Да	1,00	•	1,00	•
	4—1	100	7	14,3	15,5	•	14,7	13,4	Нет	0,89	•	0,50	•
27 II	tot.	400	7	19,2	12,6	Нет	20,6	14,1	•	0,74	•	0,78	•
	1—2	100	2				25,6	11,6	•			0,07	Нет
	2—3	100	4				3,42	12,6	Да			0,99	Да
	3—4	100	2	7,16	6,0	•	9,12	11,1	•	0,93	•	0,78	•
	4—1	100	4	10,5	12,6	Да	10,6	12,6	•	0.99	•	0.97	•

continuation of Table 3:

Дата	Номер промерной линии	1								2			
		Кривая Пирсона					Нормальная кривая			Кривые Пирсона		Нормальная кривая	
		Число измерений	Вид кривой	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_0	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_0	$K(\lambda)$	Оценка H_0	$K(\lambda)$	Оценка H_0
28/III	tot.	400	1	48,1	9,5	Нет	88,6	12,6	Нет	0,11	Да	0,005	Нет
	1—2	100	2				45,6	14,1	.			0,002	.
	2—3	100	6				72,5	22,4	.			0,17	Да
	3—4	100	1	3,14	12,6	Да	8,58	14,1	Да	1,00	.	0,89	.
	4—1	100	1	9,67	7,8	Нет	16,4	11,1	Нет	0,34	.	0,41	.
Oygaing													
1971 29/I	tot.	400	1	9,87	14,1	Да	73,2	18,3	Нет	0,86	Да	0,001	Нет
	1—2	100	1				61,7	22,4	.			0,001	.
	2—3	100	1	25,2	9,5	Нет	42,9	16,9	.	0,35	.	0,009	.
	3—4	100	2	17,8	18,3	Да	18,2	19,7	Да	0,79	.	0,96	Да
	4—1	100	1				24,3	16,9	Нет			0,02	Нет
30/III	tot.	400	2	9,10	14,1	.	8,71	16,9	Да	1,00	.	1,00	Да
	1—2	100	2	19,0	19,7	.	20,2	22,4	.	0,85	.	0,96	.
	2—3	100	1	11,8	14,1	.	5,20	9,5	.	0,98	.	0,89	.
	3—4	100	1	11,1	11,1	.	12,6	14,1	.	0,96	.	0,79	.
	4—1	100	2	2,45	12,6	.	4,69	15,5	.	1,00	.	1,00	.
1972 31 I	tot.	400	2	17,6	16,9	Нет	17,7	19,7	.	0,89	.	0,98	.
	1—2	100	1	18,2	18,3	Да	7,76	14,1	.	0,96	.	0,94	.
	2—3	100	7	16,7	21,0	.	17,4	23,7	.	0,94	.	0,97	.
	3—4	100	2				21,7	22,4	.			0,38	.
	4—1	100	2	23,8	11,1	Нет	24,3	14,1	Нет	0,82	.	0,66	.

continuation of Table 3:

Дата	Номер промерной линии	1								2			
		Кривая Пирсона					Нормальная кривая			Кривые Пирсона		Нормальная кривая	
		Число измерений	Вид кривой	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_o	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_o	$K(\lambda)$	Оценка H_o	$K(\lambda)$	Оценка H_o
29 II	tot.	400	2	11,6	15,5	Да				0,96	Да		
	1—2	100	1	8,20	14,1	•	10,9	16,9	Да	0,86	•	0,95	Да
	2—3	100	1	19,7	15,5	Нет	16,4	16,9	•	0,37	•	0,86	•
	3—4	100	2	8,16	16,9	Да	8,66	19,7	•	1,00	•	0,99	•
	4—1	100	3	11,9	14,1	•	9,36	12,6	•	1,00	•	0,98	•
31 III	tot.	400	2	35,9	15,5	Нет	37,6	21,0	Нет	0,38	•	0,15	•
	1—2	100	2	12,8	7,8	•	11,9	9,5	•	0,81	•	0,29	•
	2—3	100	4				18,7	14,1	•			0,71	•
	3—4	100	2	6,76	9,5	Да	9,02	11,1	Да	0,97	•	0,82	•
	4—1	100	1	13,3	16,9	•	20,1	19,7	Нет	0,04	Нет	0,95	•
					Lednik Severtsova								
1971													
31 I	tot.	400	7	9,26	12,6	Да	25,0	14,1	Нет	0,90	Да	0,73	Да
	1—2	100	2	4,80	7,8	•	5,89	11,1	Да	1,00	•	1,00	•
	2—3	100	7	10,2	11,1	•	9,03	11,1	•	0,96	•	0,91	•
	3—4	100	1	12,2	15,5	•	17,8	18,3	•	0,96	•	0,45	•
	4—1	100	7	4,23	12,6	•	5,52	12,6	•	0,89	•	0,73	•
3 III	tot.	400	6	11,7	9,5	Нет	17,3	7,8	Нет	1,00	•	0,00	Нет
	1—2	100	1							0,99	•	0,99	Да
	2—3	100	1	5,67	6,0	Да	9,74	3,8	•	1,00	•	0,84	•
	3—4	100	1				17,2	6,0	•	0,96	•	0,28	•
	4—1	100	6	10,5	15,5	•	11,7	12,6	Да	0,98	•	0,68	•

continuation of Table 3:

Дата	Номер промерной линии	1								2			
		Кривая Пирсона					Нормальная кривая			Кривые Пирсона		Нормальная кривая	
		Число измерений	Вид кривой	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_0	$\chi^2_{выб.}$	$\chi^2_{5\%}$	Оценка H_0	$K(\lambda)$	Оценка H_0	$K(\lambda)$	Оценка H_0
31 III	tot.	400	6	15,3	16,9	Да	21,0	9,5	Нет	0,50	Да	0,01	Нет
	1—2	100	2	0,08	3,8	•	0,17	7,8	Да	1,00	•	1,00	Да
	2—3	100	1				32,7	11,1	Нет			0,002	Нет
	3—4	100	1	1,07	3,8	•	4,32	7,8	Да	1,00	•	0,99	Да
	4—1	100	6	15,0	9,5	Нет	28,6	23,7	Нет				
1972													
2 II	tot.	400	1	12,5	7,8	•	26,4	9,5	•	0,71	•	0,22	•
	1—2	100	1	2,43	9,5	Да	5,40	12,6	Да	1,00	•	0,93	•
	2—3	100	2	10,1	3,8	Нет	16,1	7,8	Нет	0,94	•	0,56	•
	3—4	100	5	18,1	3,8	•	318	14,1	•	0,47	•	0,009	Нет
	4—1	100	3	38,5	14,1	•	1811	15,5	•	0,14	•	0,08	Да
1 III	tot.	400	7	23,2	14,1	•	47,6	18,3	•	0,56	•	0,27	•
	1—2	100	4	3,01	6,0	Да	8,00	9,5	Да	0,96	•	0,73	•
	2—3	100	1				41,7	11,1	Нет			0,04	Нет
	3—4	100	4				8,91	11,1	Да			1,00	Да
	4—1	100	4				104	11,1	Нет			0,03	Нет
31 III	tot.	400	4	12,1	11,1	Нет	19,7	14,1	•	1,00	•	0,64	Да
	1—2	100	2	6,15	7,8	Да	9,22	11,1	Да	1,00	•	0,99	•
	2—3	100	1	0,21	3,8	•	5,20	7,8	•	1,00	•	0,99	•
	3—4	100	1	6,99	7,8	•	61,7	11,1	Нет	1,00	•	0,000	Нет
	4—1	100	1				2173	15,5	•			0,000	•

Key for Table 3:

1 - Table 3. Testing the hypothesis of distribution of measurements of the snow cover depth with the aid of the χ^2 (1) and Kolmogorov (2) criteria.
2 - date
3 - number of measuring line
4 - Pearson curve
5 - number of measurements
6 - type of curve
7 - χ^2_{sam}
8 - estimate H_0
9 - normal curve
10 - χ^2_{sam}
11 - estimate H_0
12 - Pearson curves
13 - normal curve
14 - estimate H_0
15 - estimate H_0
16 - Dukant-1
17 - Dukant-2
18 - yes
19 - no

In summarizing the results of the investigation, one can assert the following: when one observes the interval of independence between measurements, in which the intraset correlation is held to a minimum, the distribution of snow cover at the snow-measuring post should be assumed to be homogeneous with a nearly normal distribution. In this case, in the most general form (the area is either horizontal or has a slight slope and is even), when one has a relative error of the average of 0.10 it is sufficient to make 5 - 10 measurements at the snow-measuring post in order to obtain a mean value with a probability of 0.95, but already when one has a relative error of 0.05, the number of observations should be increased to 10 - 15.

Таблица 4

1 **Минимальное число измерений, необходимых для получения средних значений глубины снега с вероятностью 0,95**

Дата измерений 2	ε	3 Промерная линия: 4 общ.	1—2nd	2—3rd	1—3rd	3—4th	1—4th	4—1st	1—5th	1—6th	1—7th	1—8th	1—9th
5 Дукант-1													
1967													
6 II	0,05		22		89		200		120	112	26	15	10
	0,10		11				47			120		39	
21 II	0,05		15		55		222		112	326	19	26	10
	0,10		4		14		55		28	81	5	6	1
13 III	0,05		45		2891		5045		2891	272	22	19	10
	0,10		11		720		1260		720	68	6	5	1
6 Дукант-2													
9 II	0,05		45				189			481		157	
	0,10		1		22		49		32	28	6	4	2
11 II	0,05		89		189		554		222	19	148	130	449
	0,10		22		47		138		55	5	36	32	111
22 II	0,05		45	433		1540			518	22	200	189	671
	0,10		11	107		380			129	1	49	47	165
7 Кызылча													
1971													
24 I	0,05	1	1	1		4		1					
	0,10	1	1	1		1		1					
27 II	0,05	2	1	1				1					
	0,10	1	1	1				1					
28 III	0,05	19	22	15		15		19					
	0,10	4	5	4		4		4					
8 Наугарзан													
10 II	0,05	1449	433	1796		733	2368						
	0,10	358	107	443		181	584						
27 II	0,05	1666	326	821			1602						
	0,10	411	80	202			395						
9 Ойганинг													
29 I	0,05	19	19	8		8		19					
	0,10	5	5	2		2		5					
30 III	0,05	19	19			8		8					
	0,10	5	5			2		2					
1972													
31 I	0,05	8	8	6		8		6					
	0,10	2	2	1		2		1					
29 II	0,05	6	6	6		12		2					
	0,10	1	1	1		3		1					
31 III	0,05	2	1	2		2		2					
	0,10	1	1	1		1		1					

Дата измерений 2	ε	4 общ.	1–2nd	2–3rd	1–3rd	3–4th	1–4th	4th	1–5th	1–6th	1–7th	1–8th	1–9th
		3 Промерная линия											
10 Ледник Северцова													
1971													
31 I	0,05	10	4	8		12		26					
	0,10	2	1	2		3		6					
3 III	0,05	12	4	8		6		26					
	0,10	3	1	2		1		6					
31 III	0,05	112	30	89		45		179					
	0,10	28	7	22		11		44					
1972													
2 II	0,05	19	19	12		12		26					
	0,10	5	5	6		6		6					
1 III	0,05	26	30	19		12		45					
	0,10	6	8	5		6		11					
31 III	0,05	22	15	6		12		35					
	0,10	5	4	1		6		9					

Key for Table 4:

1 - Table 4. The minimum number of measurements necessary to obtain average values of snow depth with a probability of 0.95.
2 - date of measurements
3 - measuring line
4 - total
5 - Dukant-1
6 - Dukant-2
7 - Kyzylcha
8 - Naugarazan
9 - Oygaing
10 - Lednik Severtsova

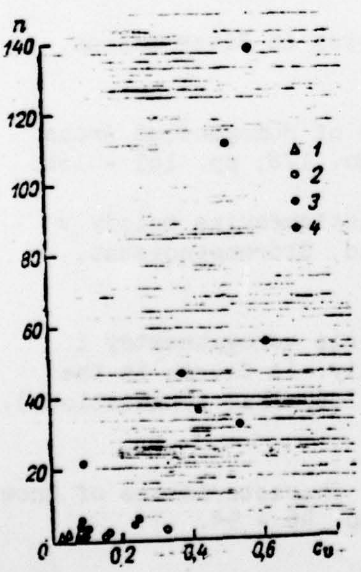

Figure 1. The relationship of the number of measurements with the brokenness terrain. Areas in basins: 1 - Kyzylcha River; 2 - Oygaing River; 3 - Kashkadar'ya River; 4 - Dukant River.

In selecting the area of the snow-measuring post, it is necessary to avoid places with wind snow redistribution (drifts, denuded spots), and if necessary to select an even area taking into account the nature of terrain brokenness.

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